**Surveillance Research Program, NCI, Technical Report #2013-01**
# Projecting Health Status Adjusted Age to Younger Ages as a Function of Comorbidity Score and Age at Diagnosis for the Cancer Survival Query System
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## Introduction

A calculator has been developed for computing net other cause survival and life expectancy as a function of age at diagnosis and comorbidity score. An overview of the methodology can be found in Feuer et al (2012), with details of its development given in Mariotto et al (under review). This calculator has been implemented in the Cancer Survival Query System (CSQS) as part of the methods used to provide crude cancer-specific, other cause, and overall survival information.

Briefly, the development of the calculator was based on a three-step process. First, using SEER/Medicare (SM) linked data, the presence or absence of a claim for 15 conditions used as part of the Charlson comorbidity index (Charlson et al., 1987) were identified in the year before a diagnosis of cancer for patients aged 66 and above diagnosed from 1992 through 2005. A Cox regression analysis was carried out to obtain the prognostic significance of these comorbidities where the event was causes of death other than cancer. A summary comorbidity score was computed as a weighted sum of the Cox regression coefficients for all patients in the SM database and also for individuals in a five-percent sample of non-cancer cases from SEER areas in the Medicare database.

In a second step, Cox regression analyses stratified by individual age and gender were conducted using other cause of death as the event. Variables in this model included race, a continuous function of comorbidity score using a restricted cubic spline, and cancer status (cancer status = colorectal, breast, prostate, head and neck, or all other cancers, or non-cancer,

i.e., the five percent sample of non-cancer Medicare patients), stage of disease (distant disease, non-distant disease, non-cancer patient). Non-cancer patients were included in the analysis to increase the available sample size, especially at older ages. Stage was included in the model, because those with distant stage disease tend to have worse other cause mortality than those who are diagnosed at earlier stages even after accounting for comorbidity. These Cox models were then used to calculate predicted survival rates up to 10 years by comorbidity score and by sex, race, cancer site, and stage for each individual age beginning with age 66 and ending with age 95.

In the final third step, the predicted other-cause survival for a specific covariate profile (i.e. age, gender, race and comorbidity score) as obtained from these Cox regression analyses was then compared to the appropriate age and gender specific 2000 US life tables (the approximate center point of the years of diagnosis included in the analysis) and the closest fit provided the basis for transforming an individual's chronologic age into a Health Status Adjusted Age (HSAA).

Because these estimates are based on Medicare data, and it takes a year of claims data to estimate comorbidity, the calculator could only be used for patients ages 66 and older. Therefore, ways were explored to determine whether there was some way to make the calculator usable for younger patients. While extrapolation is inherently unreliable, the default alternative of assuming that the HSAA is equal to the chronologic age is even more unreliable for the purpose of estimating other cause survival. After examining the interrelationship of age at diagnosis, comorbidity score, and HSAA, it was determined that it was reasonable to fit a regression model to the relationship of age at diagnosis (regressor variable) to HSAA (response variable) by comorbidity score. The model found to work best was a logarithmic model.

## Methods

As discussed above, Cox regression models were obtained by individual ages by sex that included race, comorbidity score, cancer site, and stage as covariates. These models, in conjunction with the algorithm to obtain the HSAA for a given age and comorbidity score, were used to generate the data where HSAA was computed for individual ages at diagnosis (66 - 95) and comorbidity scores (0 – 5000 in intervals of 100). Using these data and using HSAA as the dependent variable and chronologic age as an independent variable, a logarithmic model was fit for each of 51 comorbidity scores stratified by cancer site, stage, gender, and race.

The model used can be written as

$$HSAA = ae^{b(agedx)}$$

or equivalently

$$\ln HSAA = \ln(a) + b(agedx)$$

where agedx is age at diagnosis, and ln(a) = k, the intercept. . The regression coefficients were estimated by least squares, and are denoted by $\hat{k}\ and\ \hat{b}$ . The resulting models for each comorbidity score were used to project HSAA from age 65 down to age 40. The HSAA's for the comorbidity scores between those used in the modeling were obtained by linear interpolation which provided for the creation of a matrix of HSAA's for each of the 24 cancer - stage - race - sex groups with columns ranging from 40 to 95 in intervals of 1 for age at diagnosis and ranging from 0 to 5000 in intervals of 1 for comorbidity score.

The matrices for non-distant stage were reviewed to ensure that all HSAA's for comorbidity scores of 0 were less than or equal to the age at diagnosis. As a result, a few values of HSAA were set equal to age at diagnosis where the HSAA was greater than the age at diagnosis for colorectal non-distant other race males and colorectal non-distant other race

females. After these changes were made, the matrices were implemented in the CSQS for the purpose of determining HSAA and estimating other cause survival.

## Results

Figures 1 through 24 provide graphs by race, sex and age that show how well the models fit the data for the 24 groups for selected values of comorbidity score, and the projections down to age 40 are also given. Appendix I provides the model fits and projections of HSAA for values of comorbidity score ranging from 0 to 5000 in intervals of 100. The matrices in Appendix I, after obtaining HSAA's for all values of comorbidity score ranging from 0 to 5000 in intervals of 1 by interpolation, have been integrated into the CSQS so that the HSAA for patients 40-94, years old, 94 being the upper limit on age in the CSQS, can be obtained as a function of their age at diagnosis and comorbidity score.

For large values of comorbidity (i.e. above 2000) the data are quite sparse, so the relationship between comorbidity and other cause mortality is somewhat speculative. For this reason, for comorbidity values over 2000, CSQS provides a message, "Caution: Because there are very few patients in our database with as many and/or as severe co-morbid health conditions as you have selected, the calculated health adjusted age is less reliable than for individuals with fewer and/or less severe comorbidities." In addition, because the HSAA for those under age 66 is a projection, we provide the following message "Caution: Health adjusted ages for those under age 66 are projected from estimates based on Medicare data for those 66 and above. Users should be aware that these projected estimates of health adjusted age for those below age 66 are inherently less reliable."

## References

Feuer EJ, Lee M, Mariotto AB, Cronin KA, Scoppa S, Penson DF, Hachey M, Cynkin L, Carter GA, Campbell D, Percy-Laurry A, Zou Z, Schrag D, Hankey BF The Cancer Survival Query System: making survival estimates from the Surveillance, Epidemiology, and End Results program more timely and relevant for recently diagnosed patients**.** ***Cancer*****.** 2012 Nov 15;118(22):5652-62.

Mariotto AB, Wang Z, Klabunde C, Cho H, Das B, Feuer EJ. Health-Adjusted Age: A Tool for Assessing Non-Cancer Survival of Recently Diagnosed Cancer Patients. Under review.

Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. ***J Chronic Dis.*** 1987;40:373-383.

Note: Appendix 1 – Projecting Health Status Adjusted Age to Younger Ages may be found at: http://surveillance.cancer.gov/reports/tech2013.01.appendix1.xls

**Figure 1. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Non-distant, White Females.**

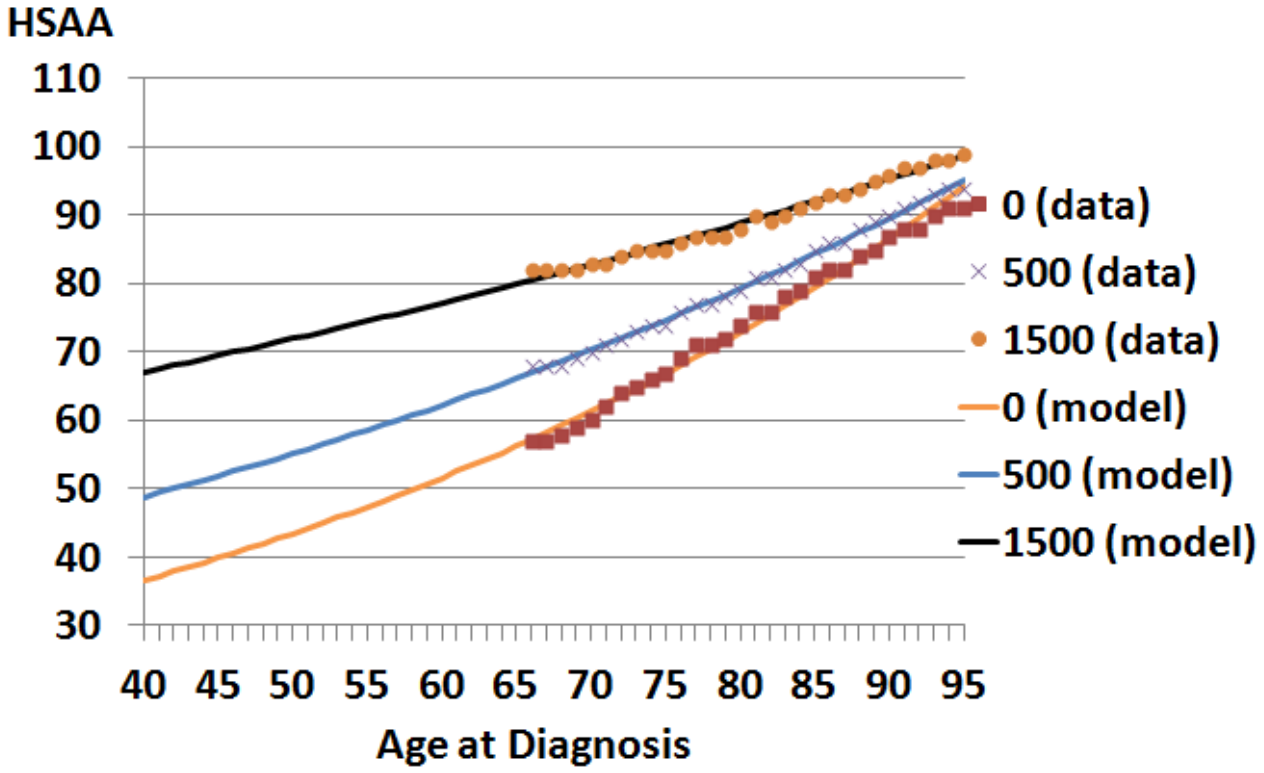


**Figure 2. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Non-distant, Black Females.**

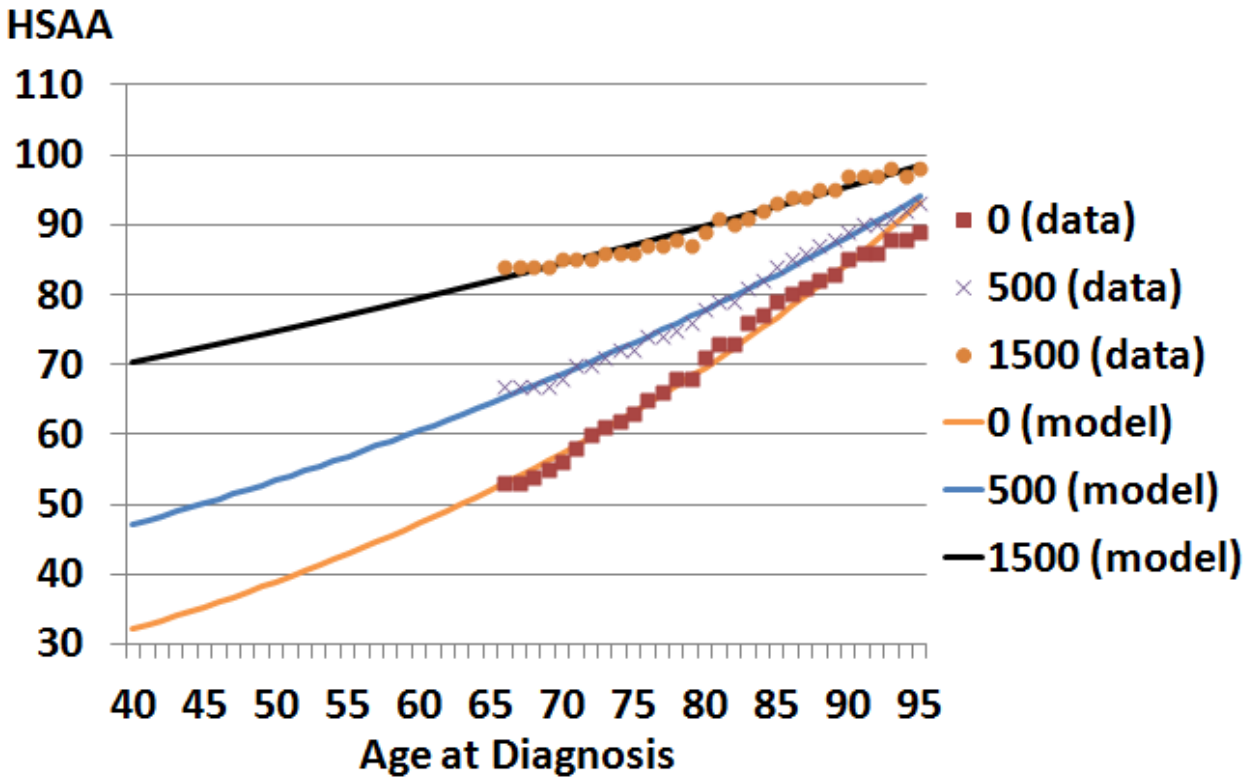


**Figure 3. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Non-distant, Other Females.**

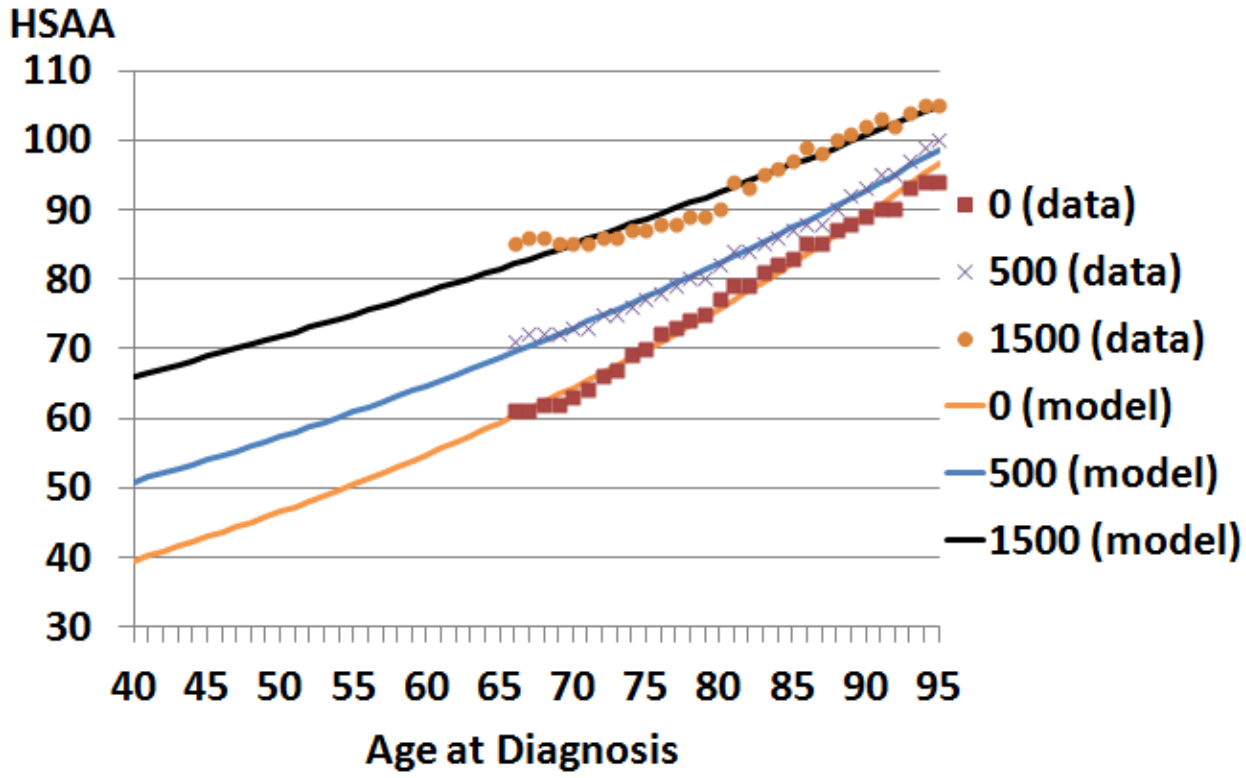


**Figure 4. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Distant, White Females.**

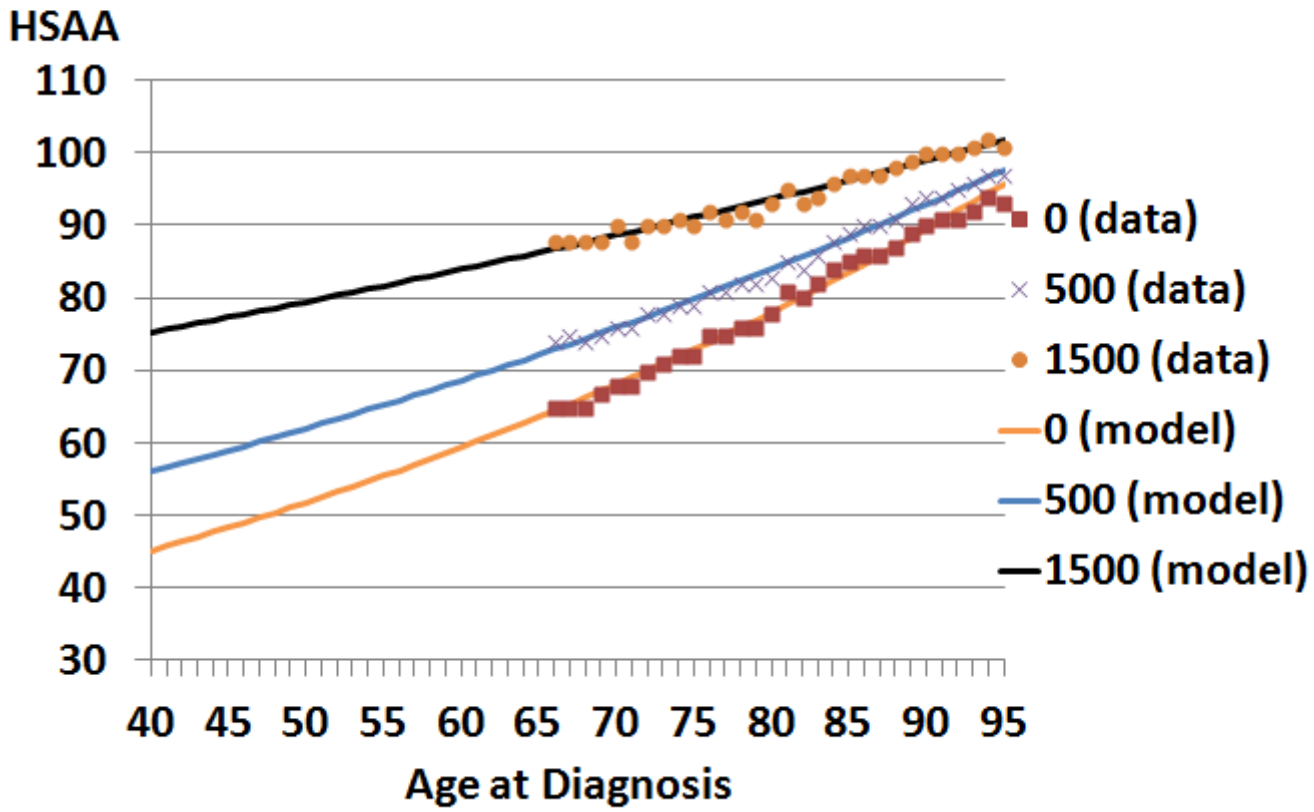


**Figure 5. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Distant, Black Females.**

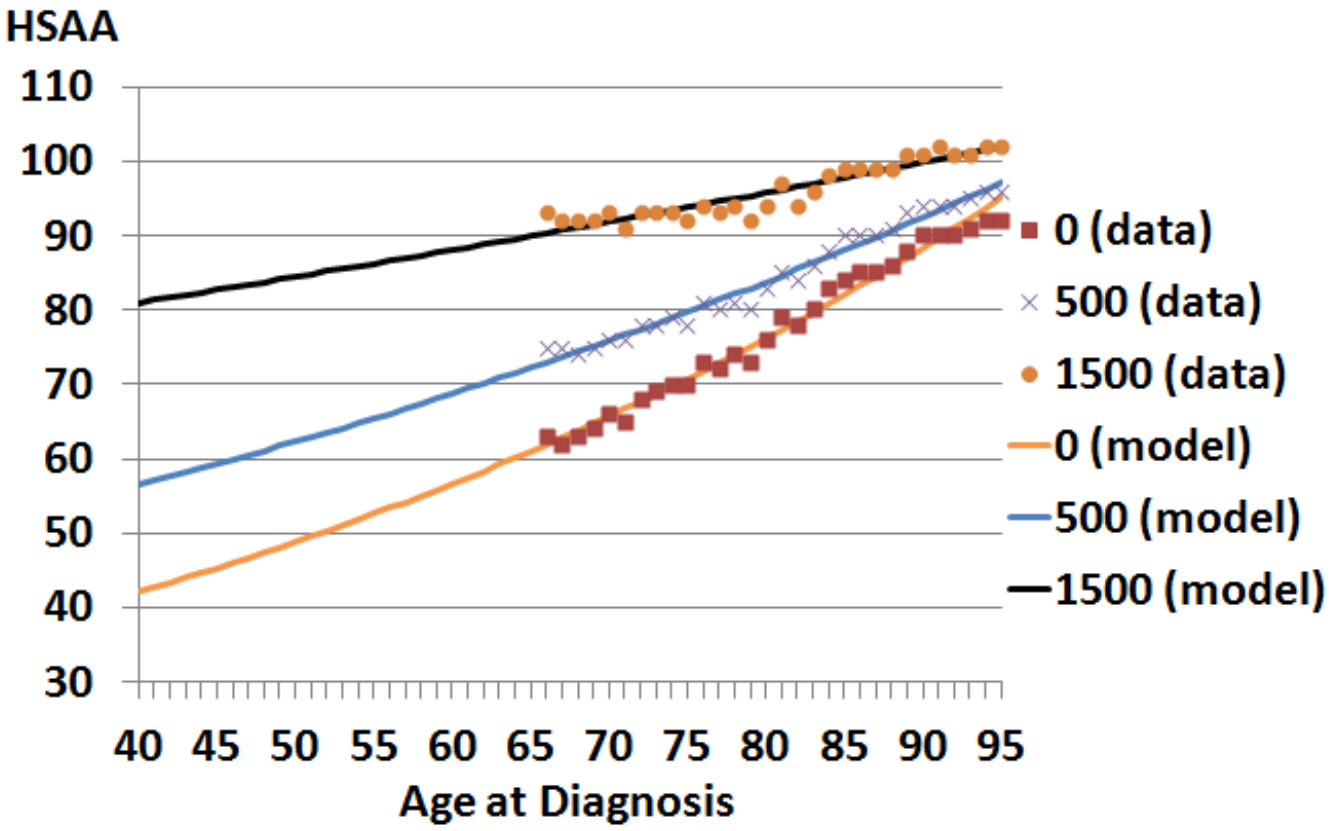


**Figure 6. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Breast, Distant, Other Females.**

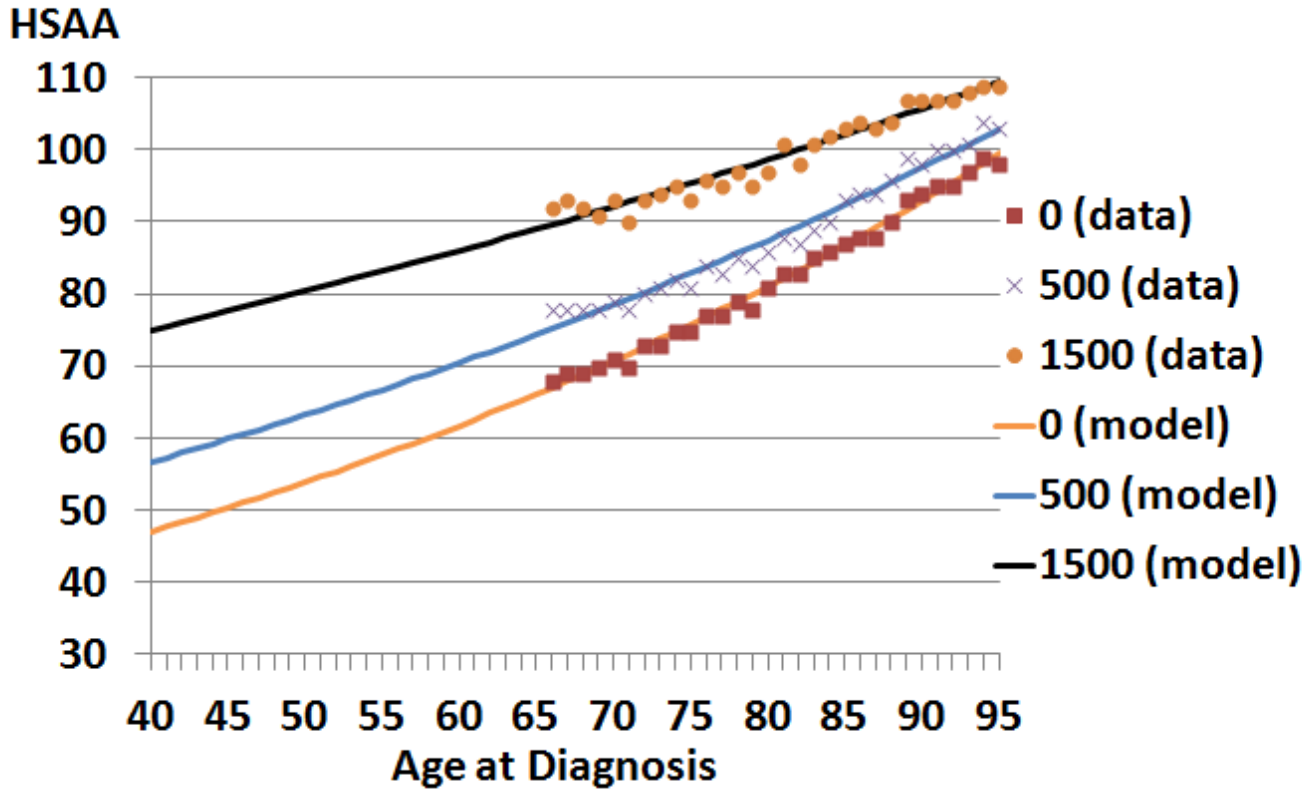


**Figure 7. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Non-distant, White Males.**

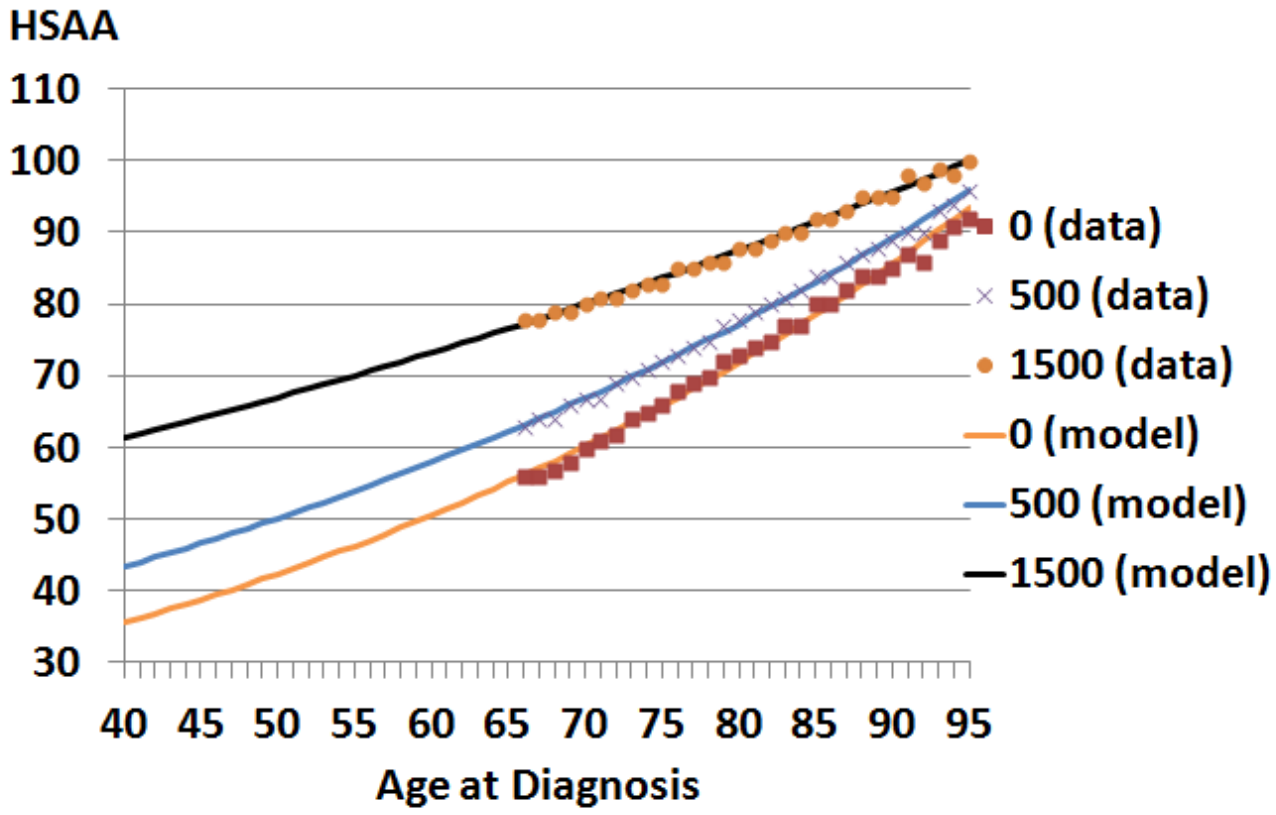


**Figure 8. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Non-distant, Black Males.**

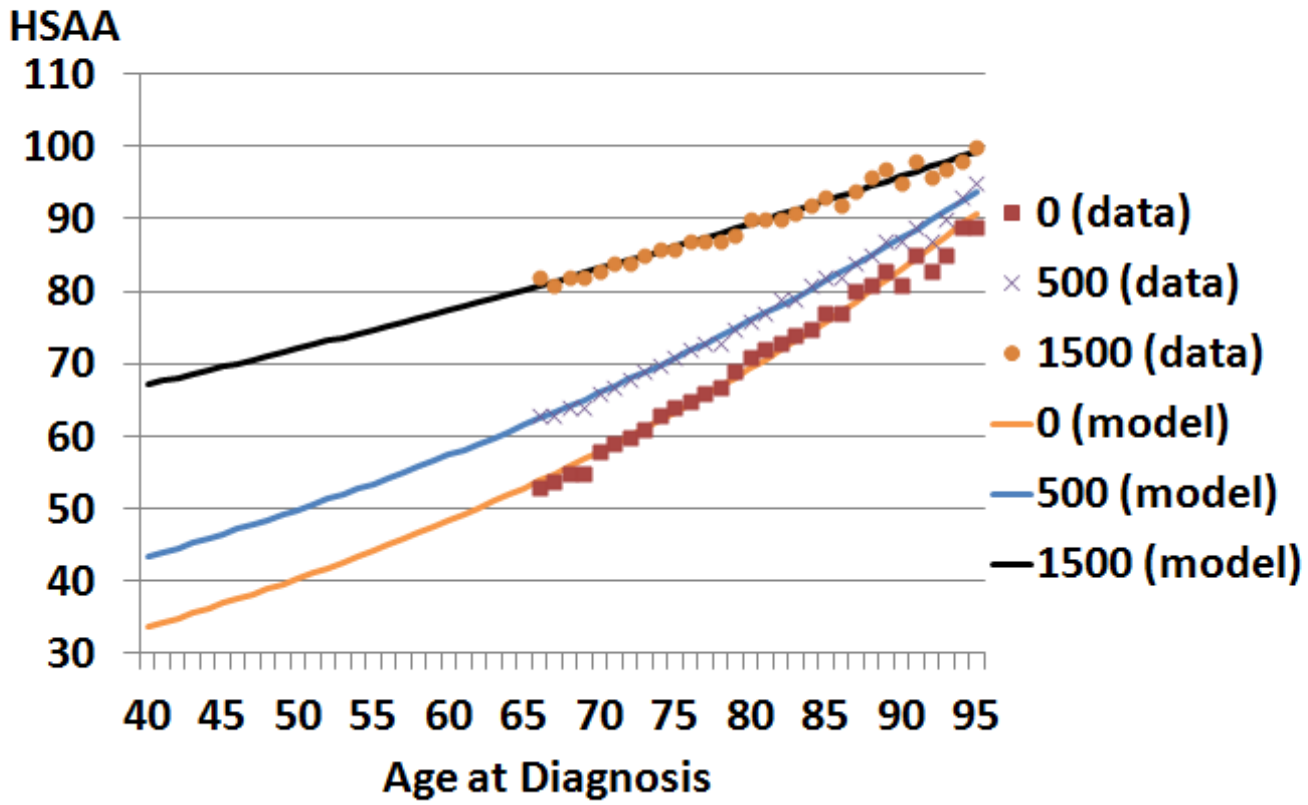


**Figure 9. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Non-distant, Other Males.**

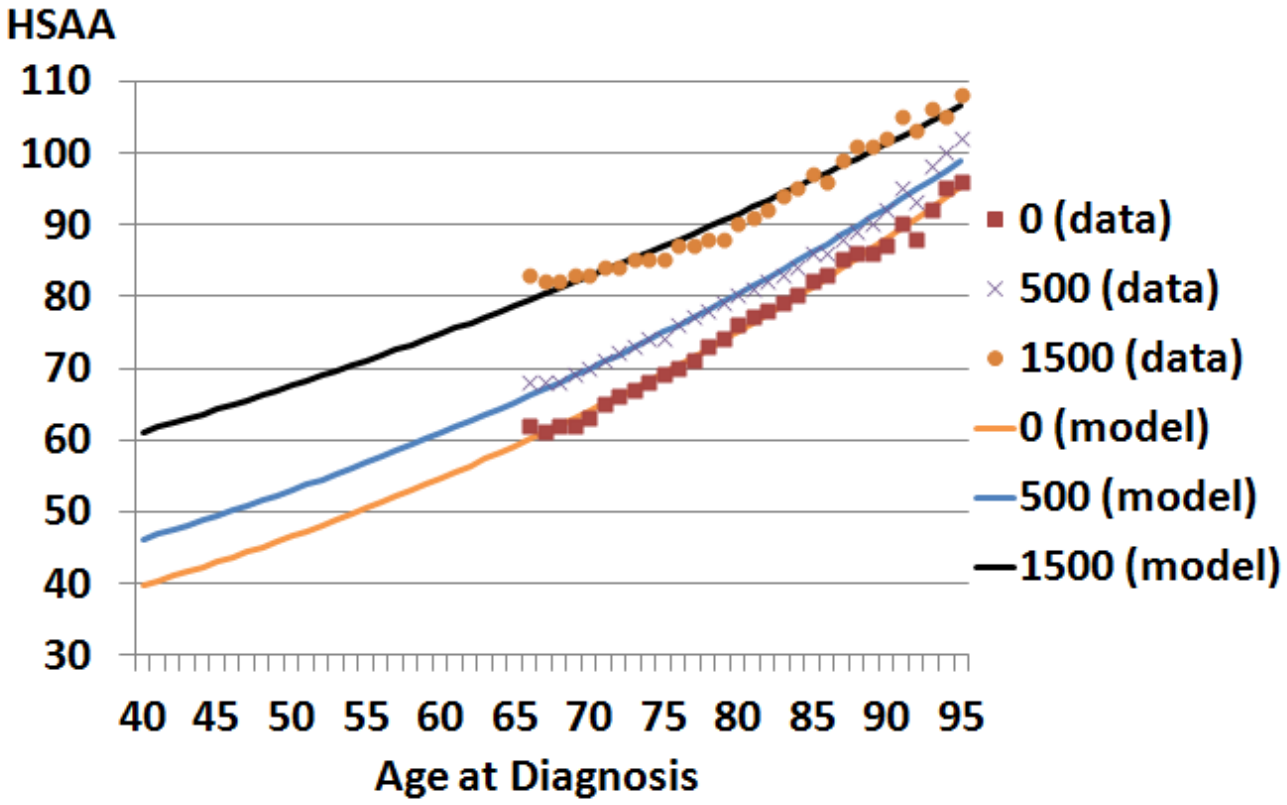


**Figure 10. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Distant, White Males.**

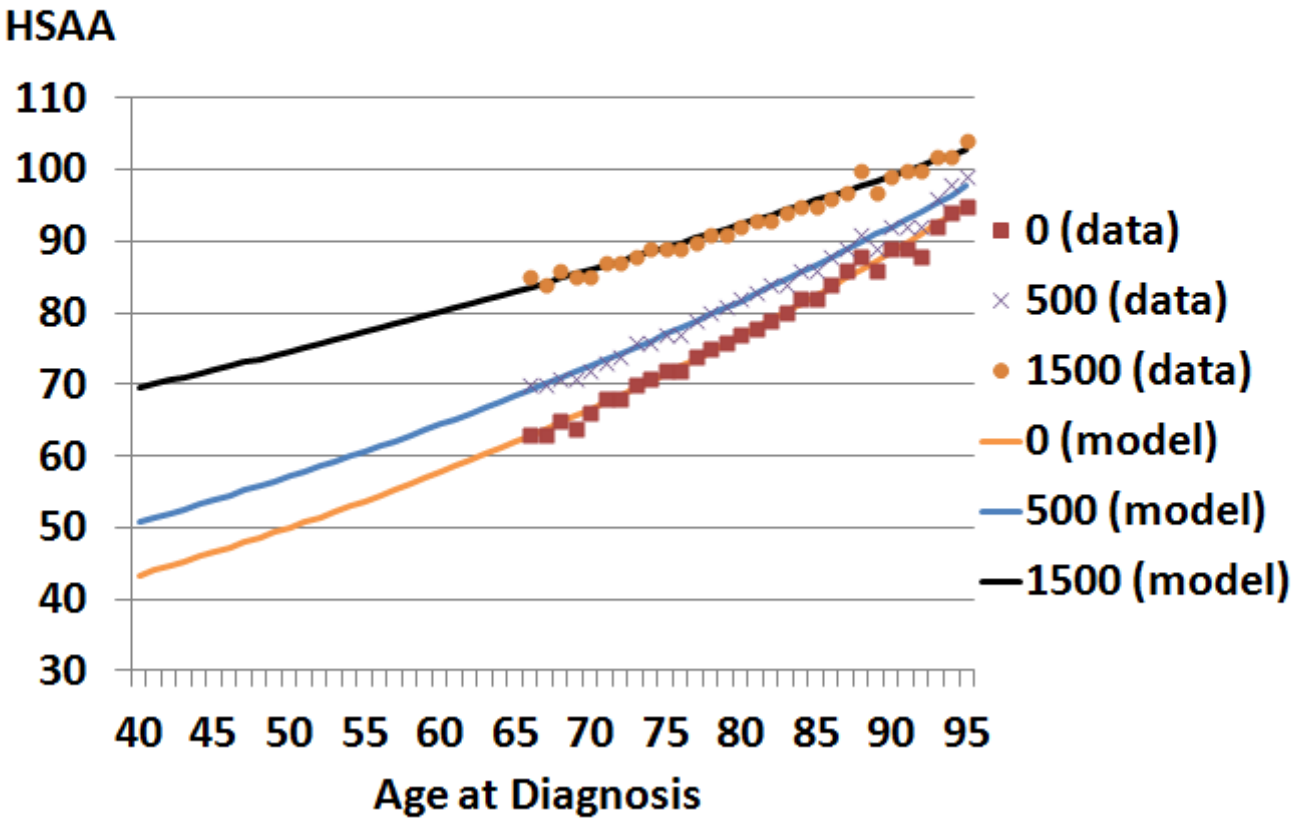


**Figure 11. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Distant, Black Males.**

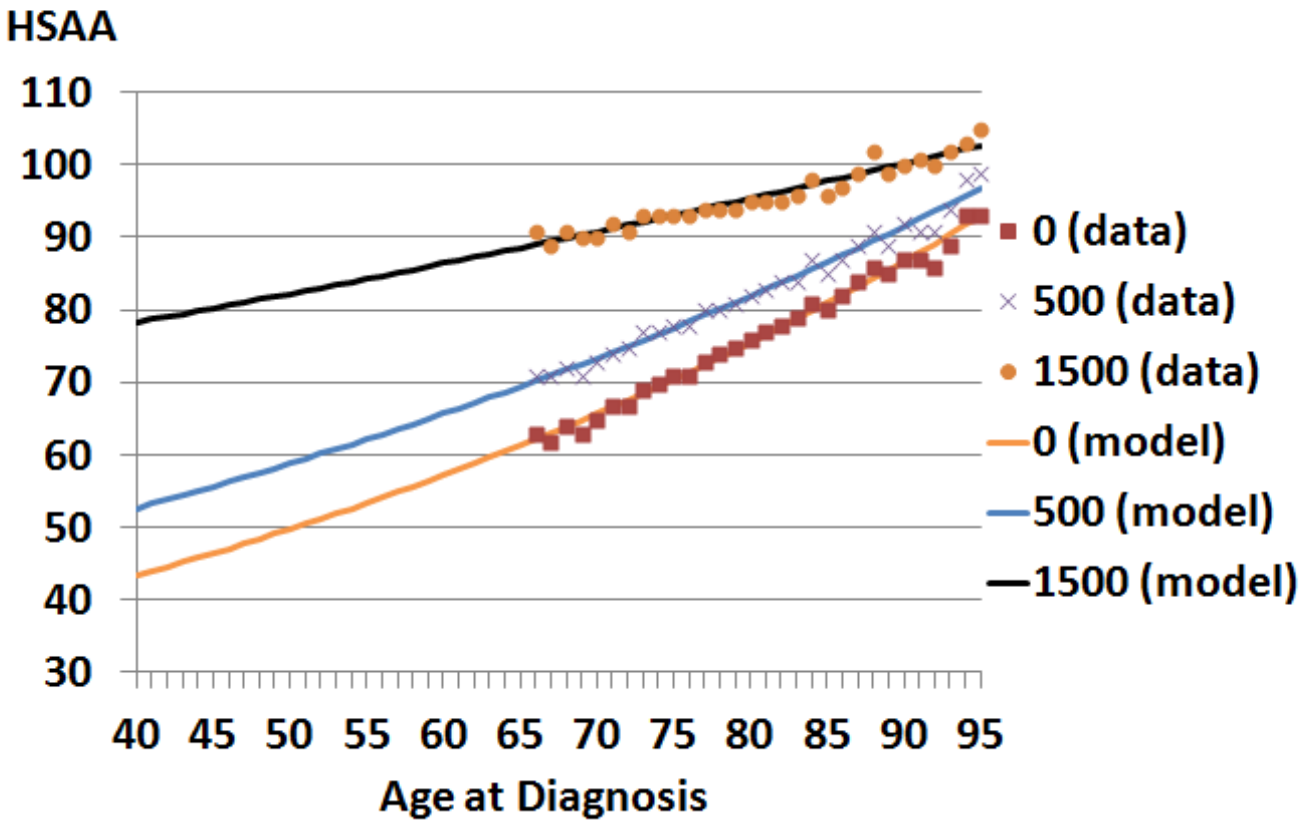


**Figure 12. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Prostate, Distant, Other Males.**

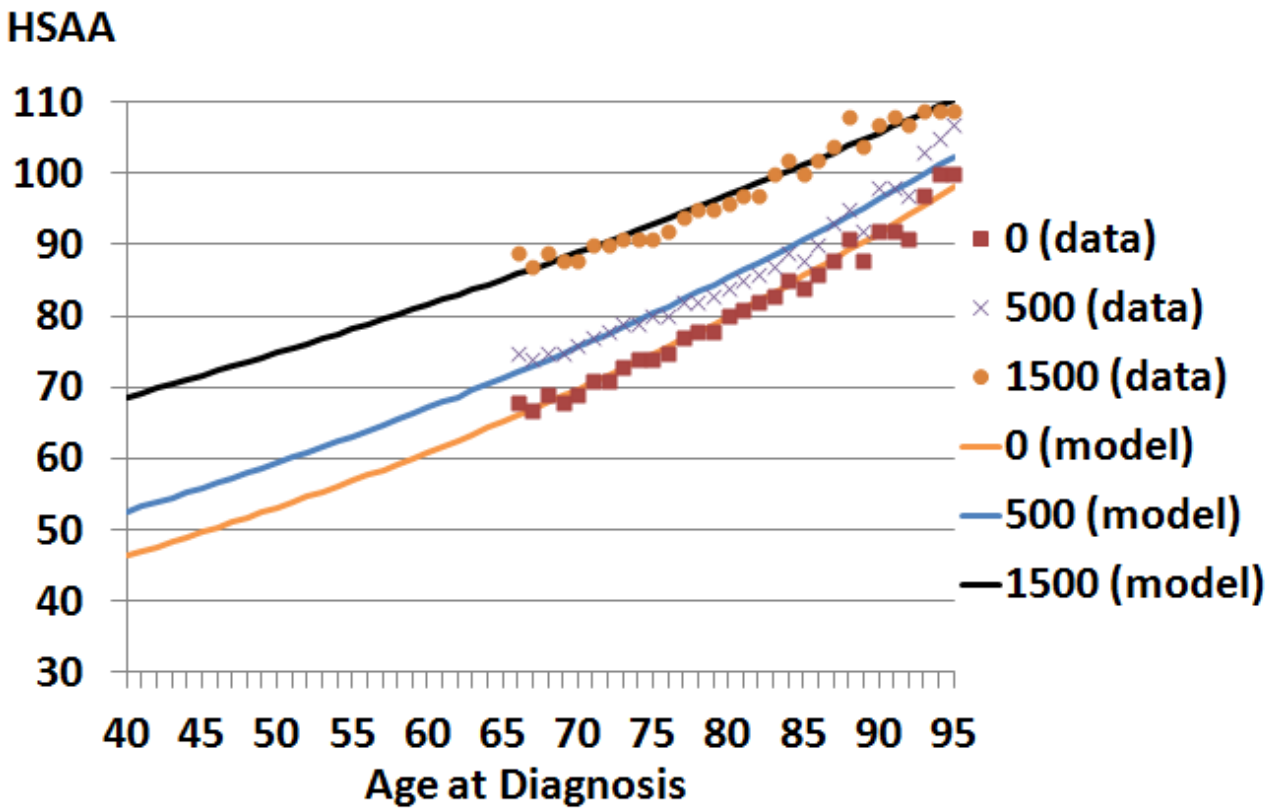


**Figure 13. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, White Females.**

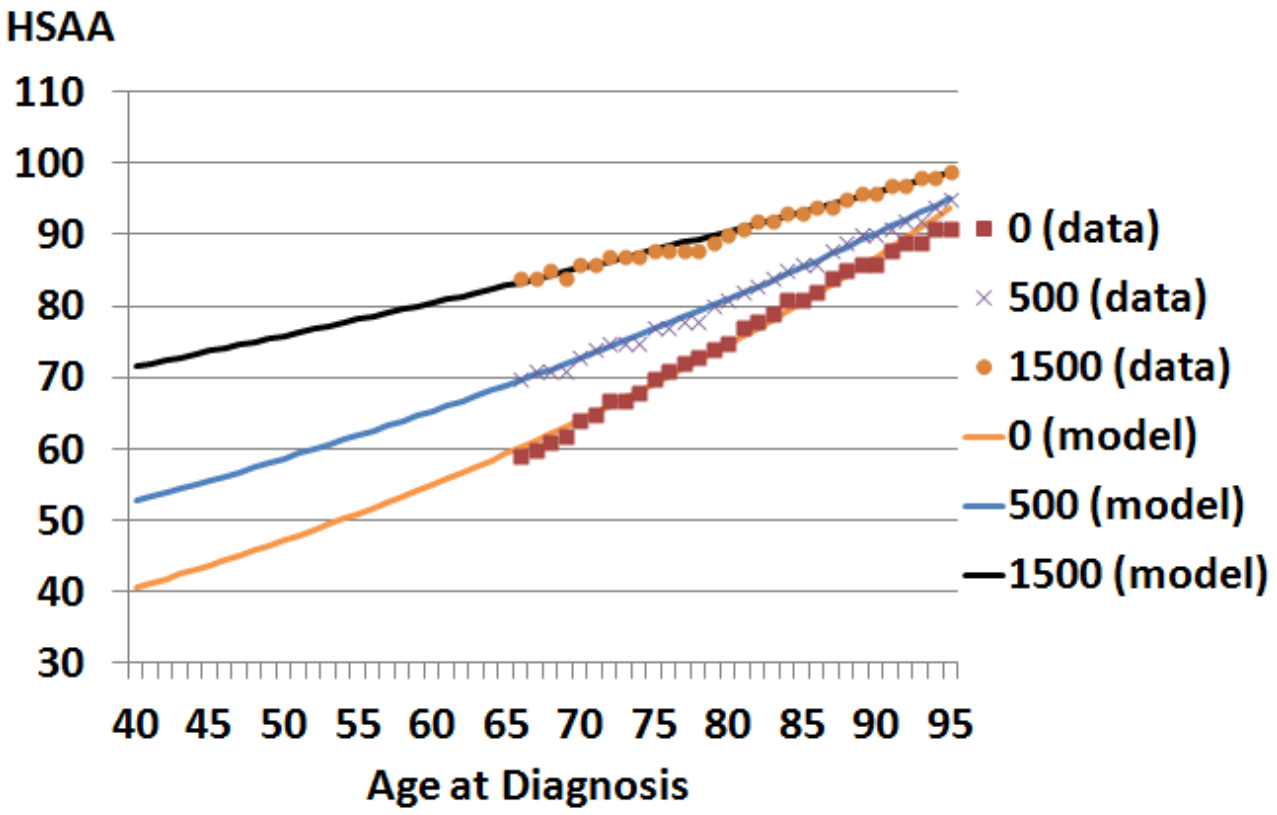
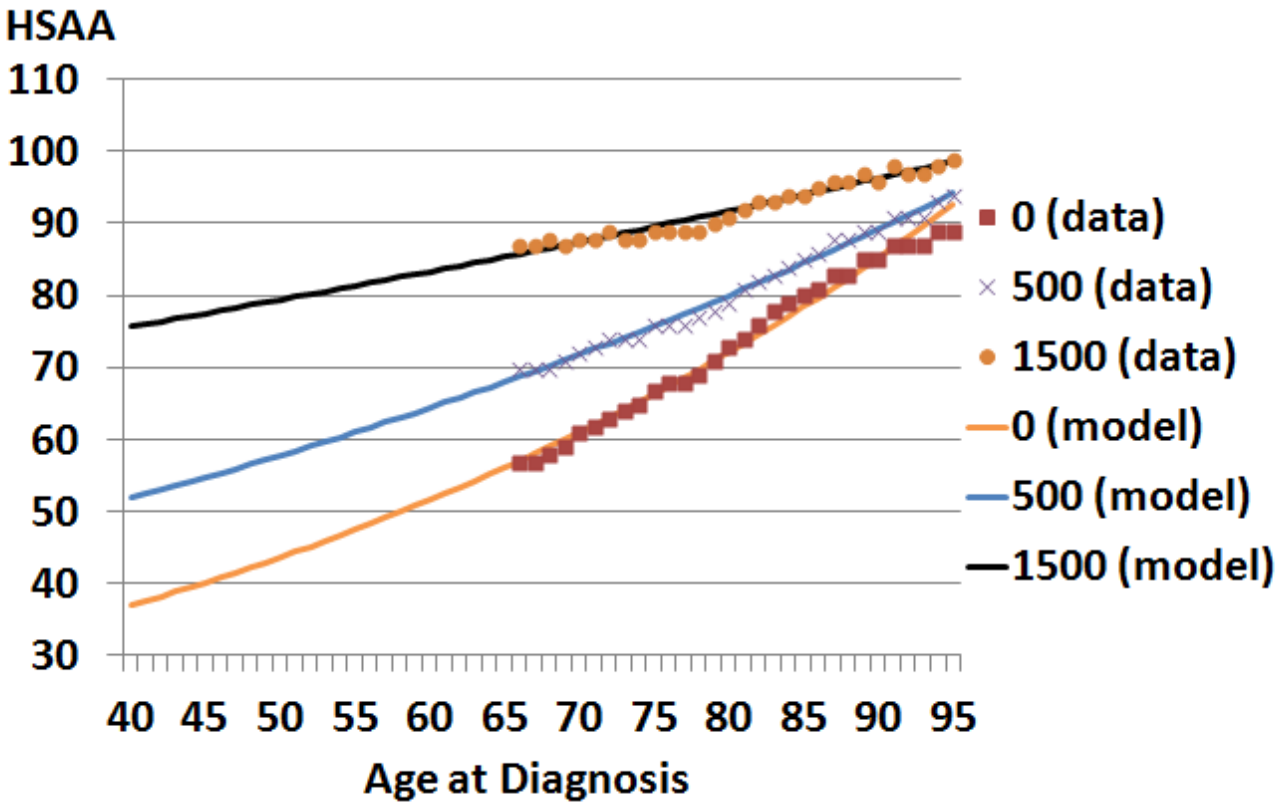
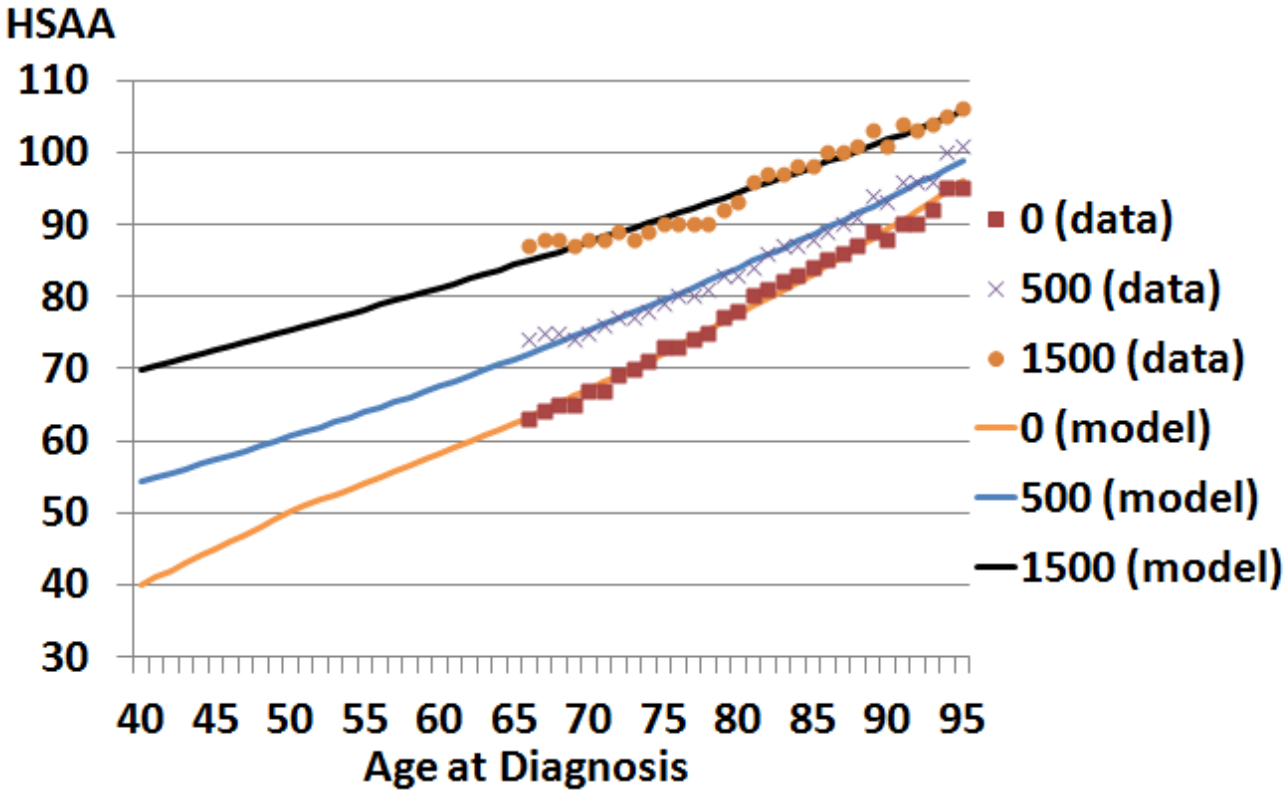


**Figure 14. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, Black Females.**

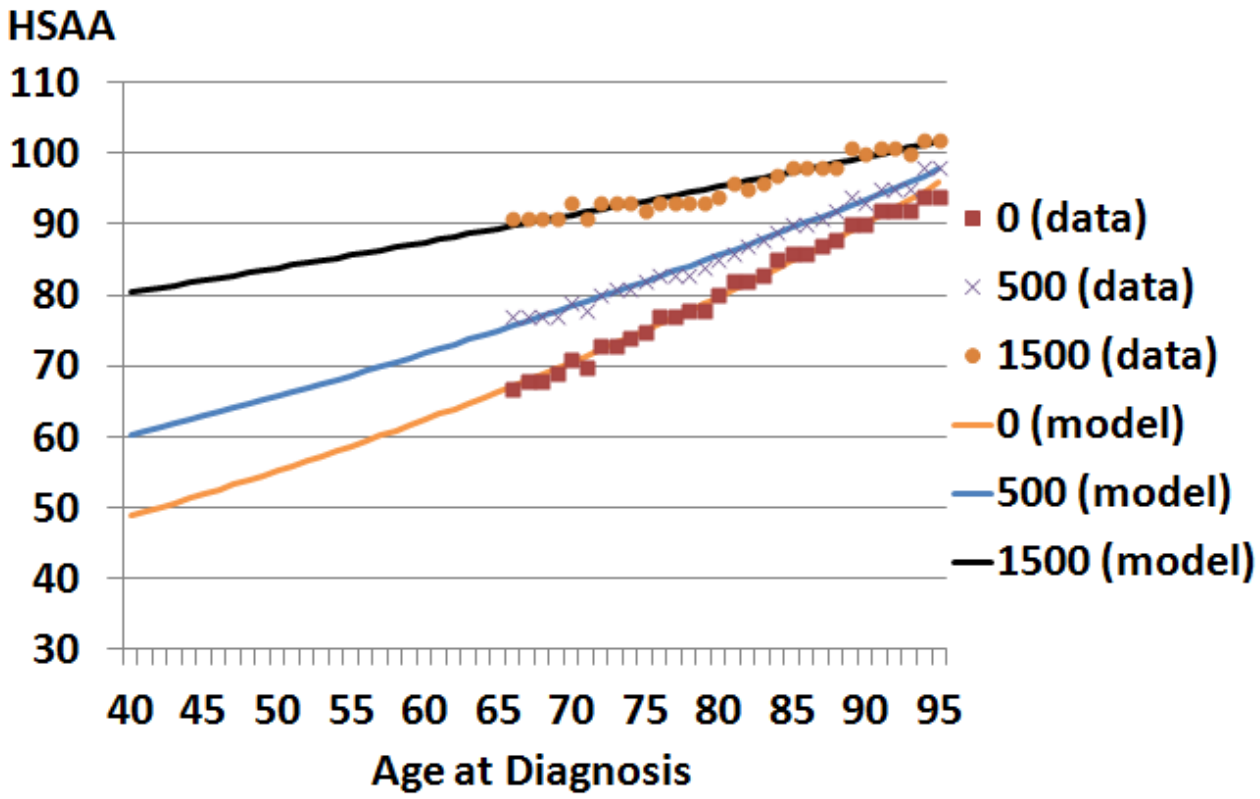


## Figure 15. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, Other Females.




**Note:** HSAA's modified where necessary so that all of them are less than or equal to the age at diagnosis for a comorbidity score of zero.

**Figure 16. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, White Females.**



## Figure 17. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, Black Females

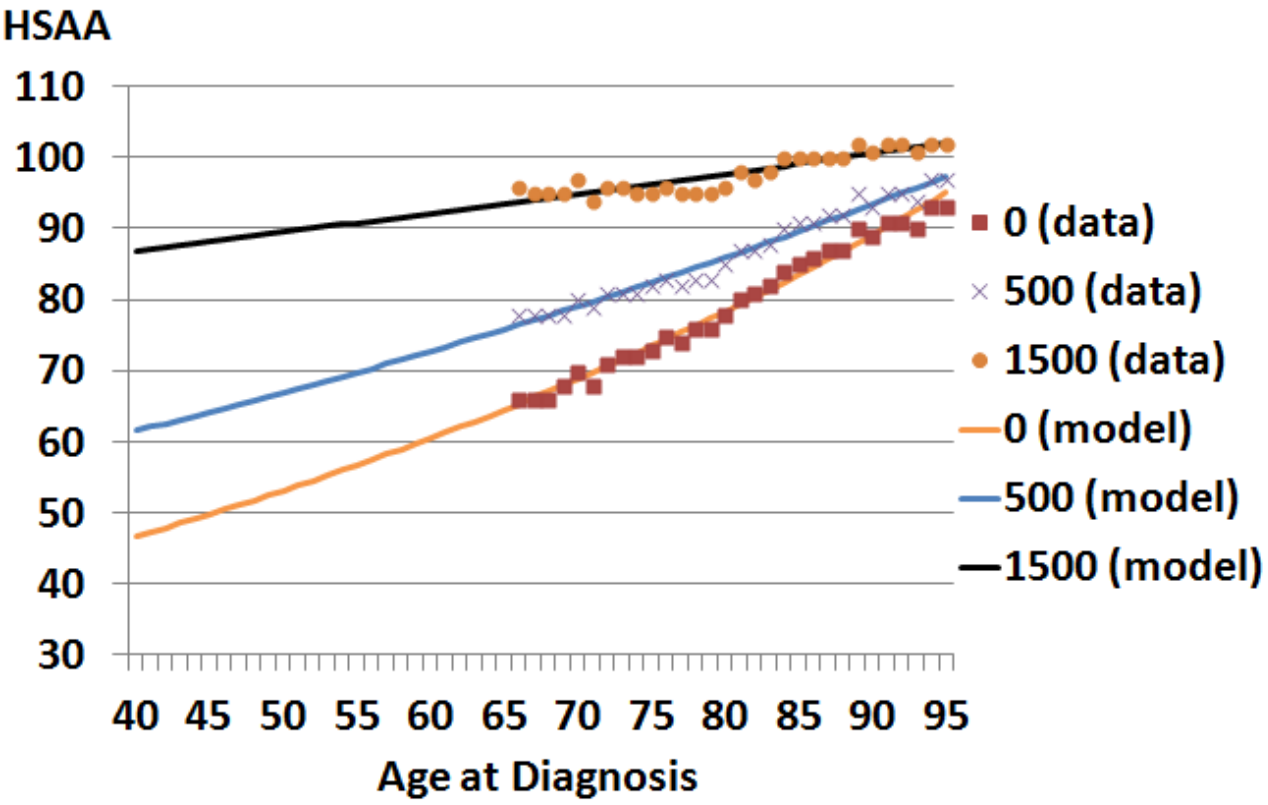


**Figure 18. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, Other Females.**

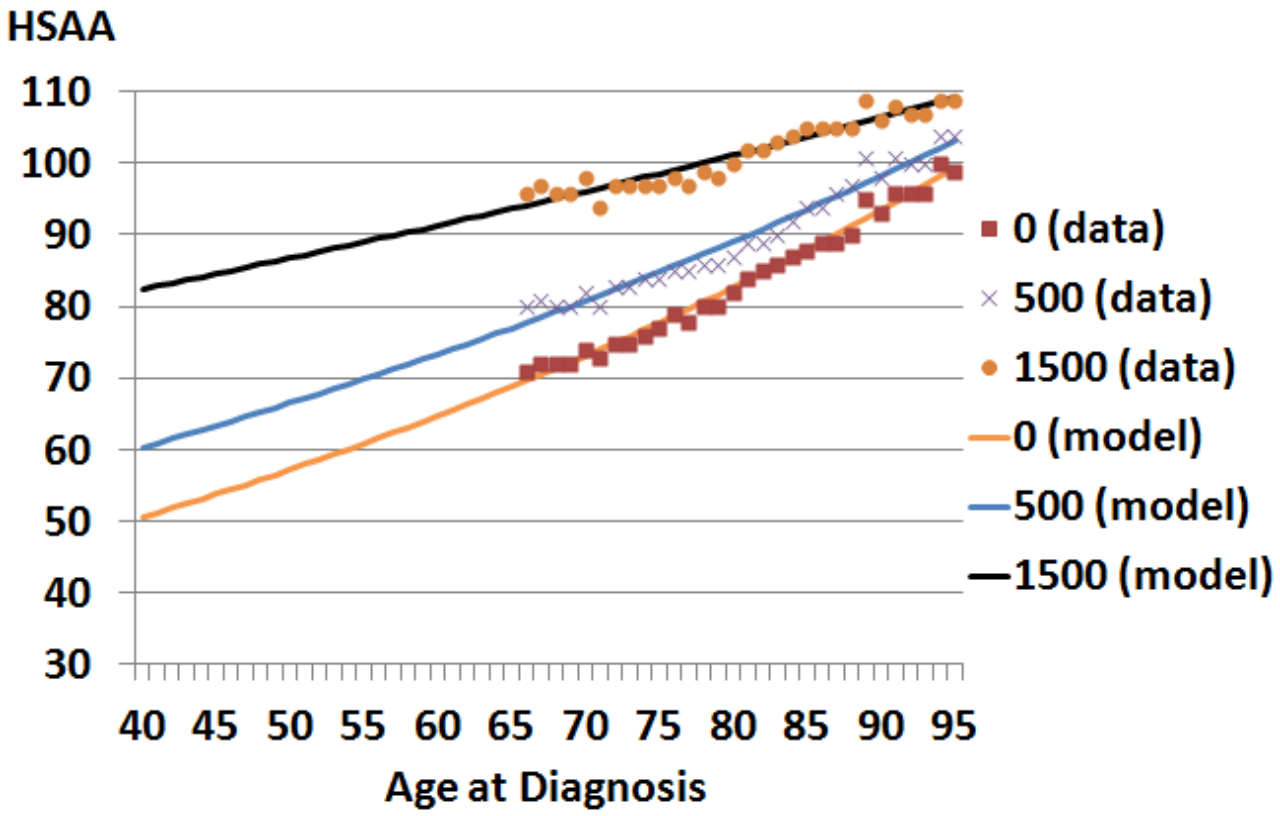


**Figure 19. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, White Males.**

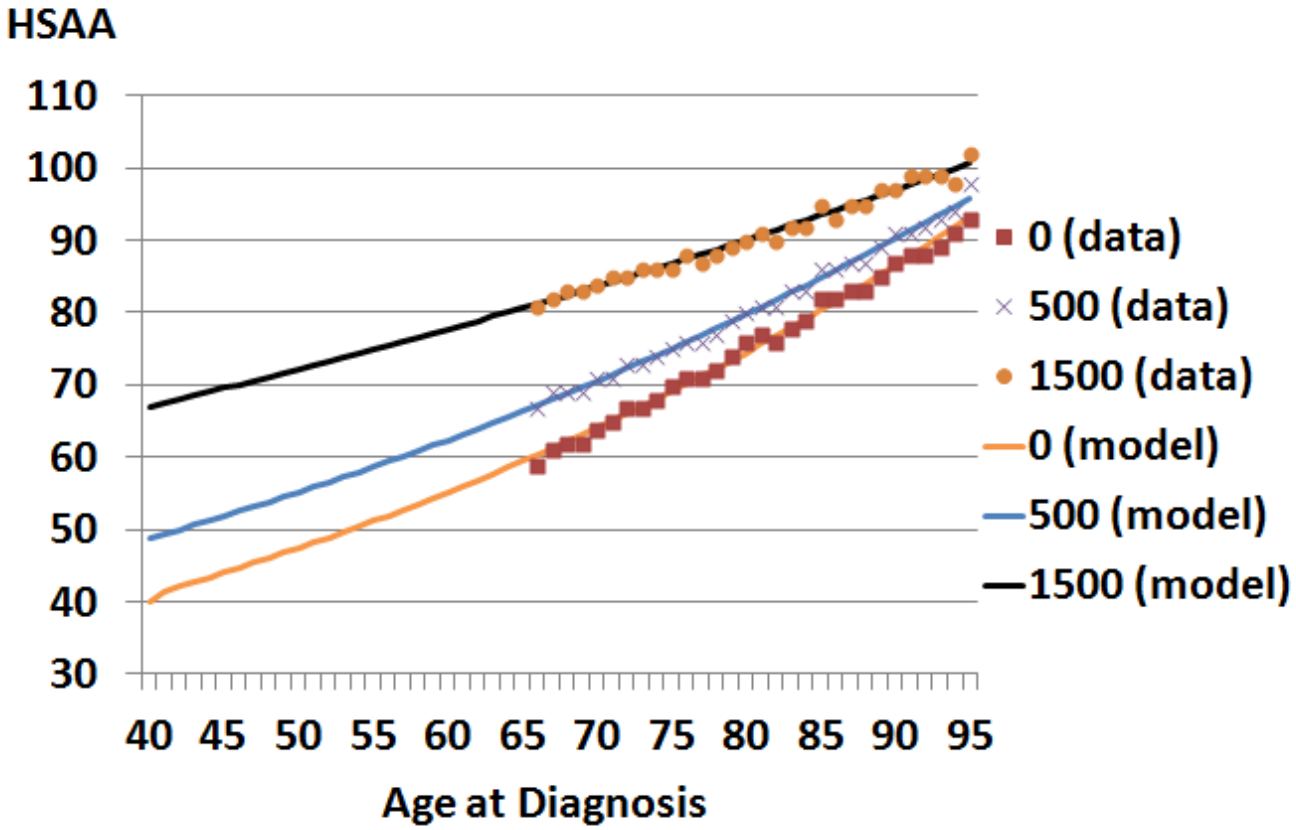
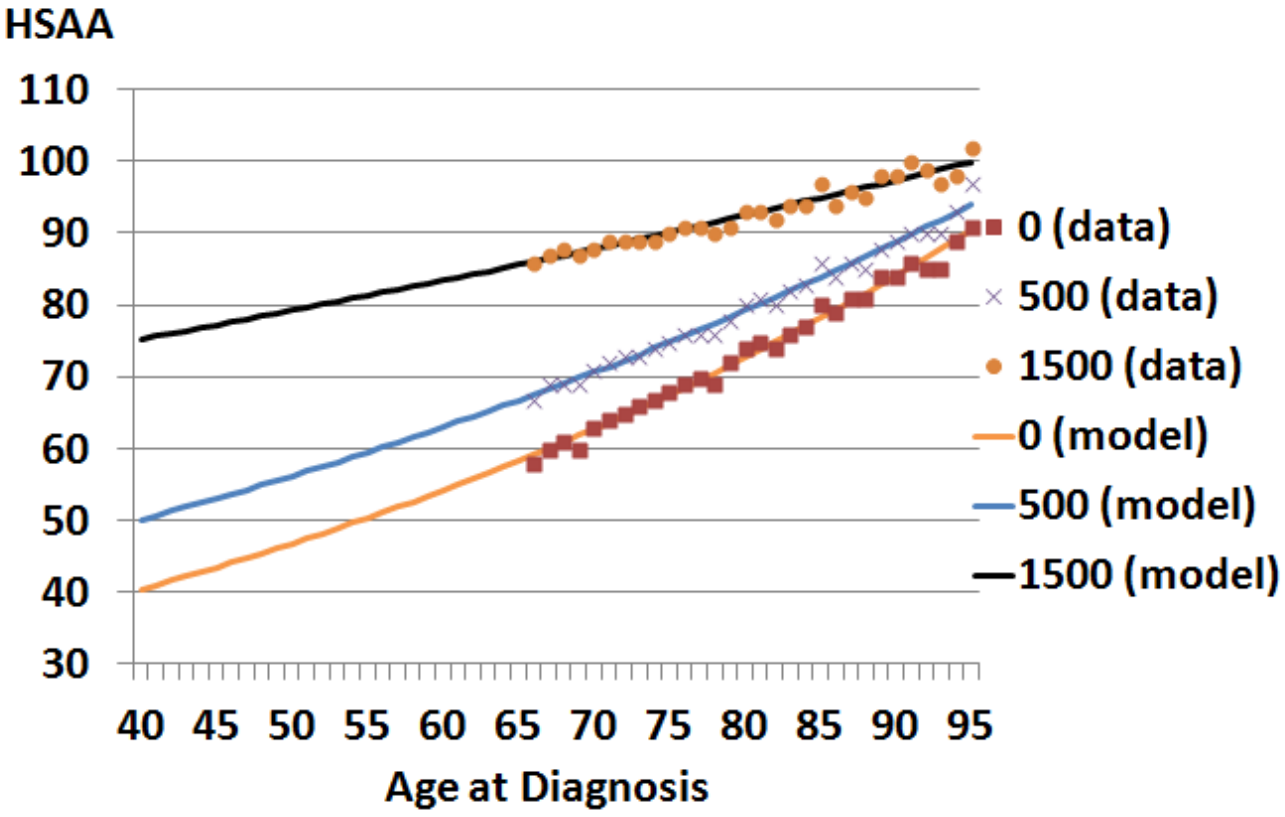
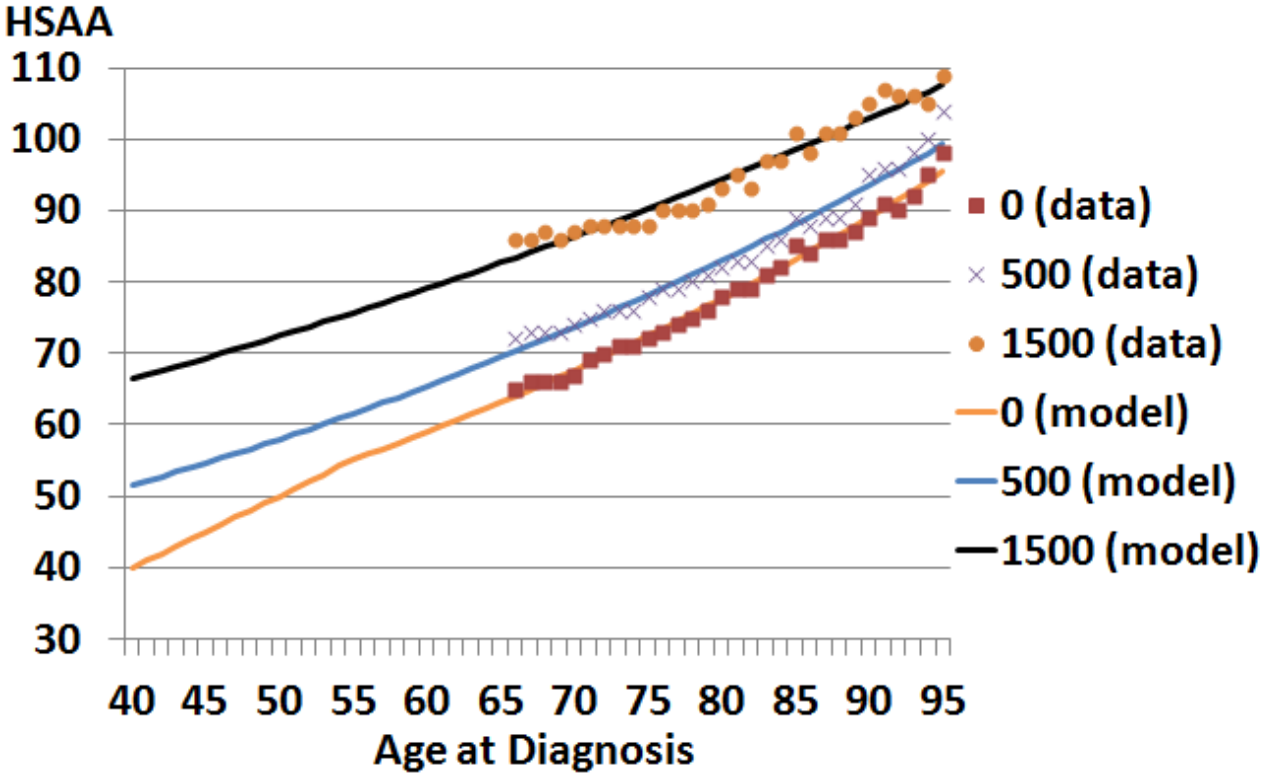


**Figure 20. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, Black Males.**



## Figure 21. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Non-distant, Other Males.




**Note:** HSAA's modified where necessary so that all of them are less than or equal to the age at diagnosis for a comorbidity score of zero.

**Figure 22. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, White Males.**

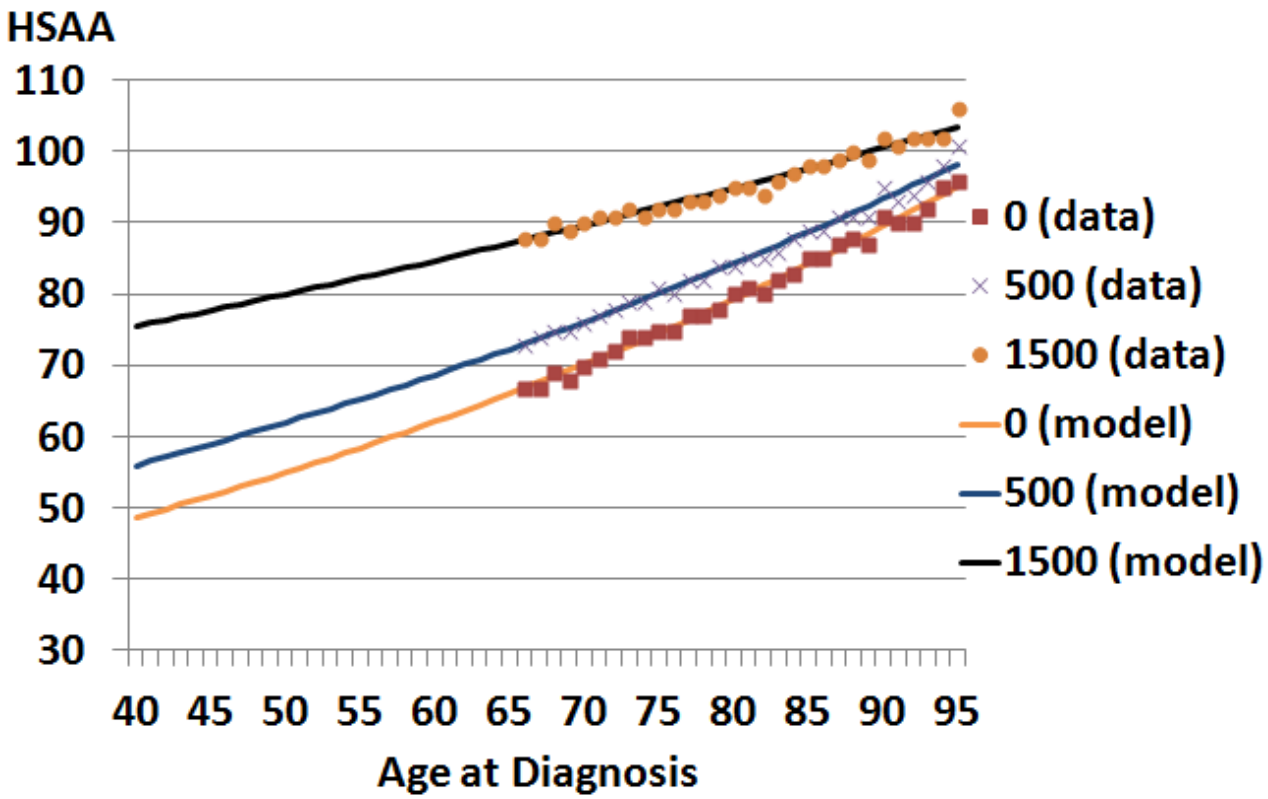


**Figure 23. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, Black Males.**

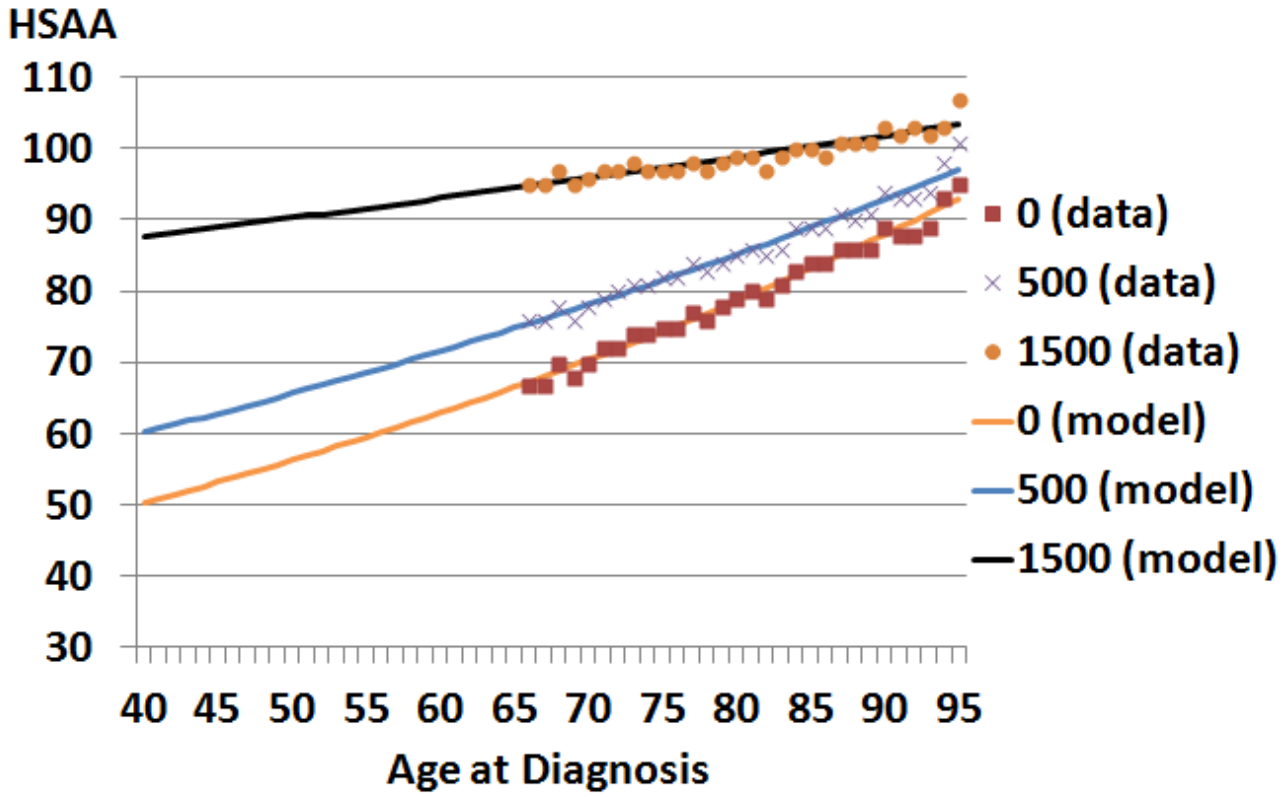


**Figure 24. Health Status Adjusted Age (HSAA) by age at diagnosis and comorbidity score; Colorectal, Distant, Other Males.**